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Remarks:
Claims 11 & 12 are deemed to be abandoned due to non-payment of the claims fees (Rule 31 (2) EPC).

(54) Improved grinding process

(57) A grinding machine, particularly for grinding the crankpins (12) of a crankshaft, comprising a CBN grinding wheel (10) and a coolant nozzle (14) supplying a jet of coolant into the region being ground. During the final stage of grinding, when the slow feed of the wheel ceases and the dwell point is reached, a selector valve (18) is operated which reduces the coolant flow. This in turn reduces the lateral force on the crankpin and improves the roundness accuracy of the ground crankpin.

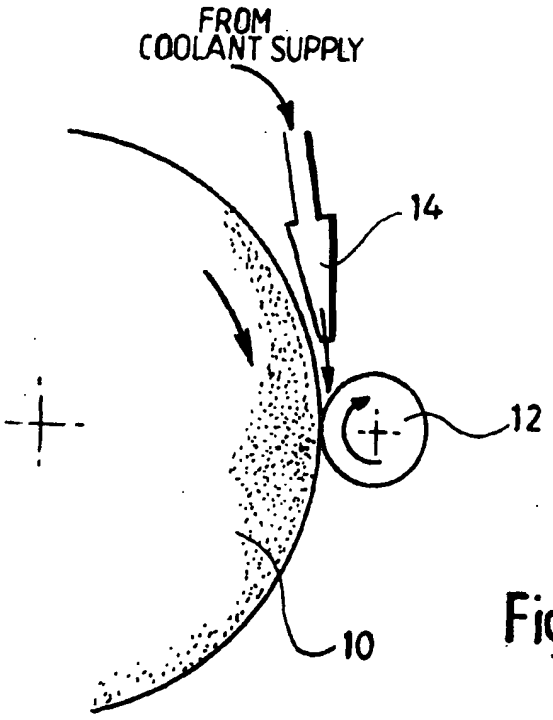

Fig. 1

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Description

Field of the invention

[0001] This invention concerns grinding machines and grinding methods.

Background to the invention

[0002] The use of CBN wheels in grinding processes has resulted in the requirement for large volumes of coolant to be delivered at ever higher pressures and velocity. CBN wheels tend to have a higher density an lower porosity than conventional Aluminium Oxide wheels. Grinding forces are higher and it is possible that the coolant contributes to the generation of high dynamic forces between the grinding wheel and the workpiece.

[0003] In order to grind at ever higher production rates and optimise maximum wheel life, it has been necessary to continue to increase coolant flows and pressures. In parallel with this it has been observed that profile quality and consistency in ground parts has deteriorated.

Summary of the invention

[0004] According to one aspect of the invention in a method of grinding a workpiece, the grinding process is monitored and during a predetermined final stage of a grind cycle, shortly before final size is reached, the flow of coolant at least onto the region of the workpiece that is being ground, is altered for at least part of the duration of the said predetermined stage of the grind cycle.

[0005] The method is particularly applicable when grinding with a CBN grinding wheel.

[0006] Using the method of the invention, it has been found that a cam lobe profile can be improved and grinding errors in the final size reduced from 10's of microns to 2 or 3 microns during finish grinding, if the coolant flow is reduced or at least in part directed away from the region of engagement during the grinding of the final 20 microns down to final size.

[0007] In a similar manner, using the grinding method of the invention, the out-of-roundness of a crankpin has been reduced from a 10 micron envelope to an envelope of less than 1 micron, by reducing or deflecting or even removing the high pressure coolant flow when the component was 25 microns above final size, and maintaining the reduced or deflected flow (or turning off the flow) for the duration of the final 25 micron grind.

[0008] Even more surprisingly the width between side cheeks of a crankpin bearing even during a rough grind operation has been maintained more constant, therefore maintaining them parallel, by reducing or deflecting or removing the coolant flow during the last stage of grinding the two parallel faces.

[0009] According to another aspect of the invention a grinding machine comprises a grinding wheel, drive means for rotating same to effect grinding of a workpiece, means for rotating the latter during grinding, means for effecting relative movement between the grinding wheel and the workpiece to bring the wheel and workpiece into engagement for grinding and to maintain such engagement for the duration of a grinding cycle, means for directing a jet of coolant liquid onto the wheel, or the workpiece, or both, at least in the region of the engagement of the wheel and the workpiece, further comprising: jet controlling means for controlling the direction of the jet and/or the rate of flow of coolant liquid from the jet, means for sensing when a grind cycle is nearing completion and the workpiece has a predetermined oversize condition remaining to be ground, control signal generating means responsive to signals from the sensing means, means for supplying the control signal to the jet controlling means, to alter the jet of coolant liquid so as to deflect it or redirect, it or reduce it, or shut it down completely, when the predetermined oversize condition is sensed and for at least part of the duration of the remainder of the grind cycle, and machine control means responsive to the control signal generation to resume the grinding cycle after the alteration of the coolant jet has been effected, to complete the grinding process.

[0010] The sensing means may comprise a workpiece engaging probe detecting the dimension of a part of the workpiece which is being ground.

[0011] Alternatively or in addition, the sensing means may comprise means responsive to the advance of the grinding wheel during the grinding cycle, which is programmed to deliver a signal when the grinding wheel has advanced through a given distance thereby indicating that the sad predetermined distance remains during which coolant flow is to be altered.

[0012] Where the grinding process is computer controlled and the position of the wheel relative to the workpiece and the distance to final size are both available to the computer, the coolant flow control may be achieved by signals from the computer.

Brief Description of the Drawings

[0013] The invention will now be described, by way of example only, with reference to the accompanying drawings in which:-

Figure 1 is a side view of part of a grinding machine in accordance with the invention;

Figure 2 is a schematic diagram of a control circuit for the coolant flow for the machine of Figure 1;

Figure 3 is a graph showing a typical cycle of grinding feed movement against time; and

Figure 4 is a graph showing an example of coolant flow rate, in accordance with the invention, against a time base corresponding to that of Figure 3.

Detailed Description

[0014] Referring first to Figure 1, there is shown part of a grinding machine including a CBN grinding wheel 10 rotating clockwise, as indicated by the arrow. The wheel is shown in grinding contact with a contra-rotating cylindrical workpiece 12, in this case a crankpin rotating about the main axis of a crankshaft (not shown).

[0015] In order for the wheel to follow the orbiting movement of the crankpin 12, the wheel is horizontally backwards and forwards under computer control by means known per se.

[0016] A coolant nozzle 14 feeds a jet of coolant liquid down into the zone of contact between the wheel and the crankpin. The nozzle is mounted on a wheelhead (not shown) on which the wheel 12 itself is rotatably mounted.

[0017] In view of the high metal removal rates achievable with CBN wheels, it is necessary to have a large coolant flow from the nozzle 14 during the main grinding feed. It has been found that the jet of coolant flow increases the force exerted on the crankpin being ground, and hence tends to reduce the grinding accuracy which this invention seeks to mitigate.

[0018] Figure 2 shows the control circuit for the coolant, in which a pump (not shown) feeds coolant under pressure along a supply line 16 to a solenoid operated selector valve 18 which, in this example, is under the control of the computer. The selector valve has two positions, a first normal position (as shown) in which a full flow of coolant passes through it, and is fed via line 19 to the nozzle 14, and a second position in which the flow is throttled so that a reduced flow is fed to the nozzle. The reduced flow can be adjusted by a flow control valve 20 which connects the pump to the selector valve 18 along a line 21 parallel to the line 16.

[0019] A typical cycle of grinding feed against time is shown in Figure 3. The feed rate progressively reduces from an initial fast feed 22 and a medium feed 24 down to a slow feed 26, after which there is a dwell period 28 in which the feed ceases and sizing of the workpiece occurs, in this case the crankpin 12.

[0020] In accordance with the invention, and as illustrated in Figure 4, the coolant flow is maintained at a full rate 30 during the fast feed and up to the end of the slow feed 26, whereupon the computer issues a command signal to the selector valve 18 to cut the flow down to a reduced rate 32 for the duration of the dwell period 28. At the end of the dwell period, the coolant flow is completely stopped while the grinding wheel executes a rapid retract, as shown at 34 in Figure 3. Adjustment of the control valve 20 enables the ratio of the full flow to reduced flow to be varied to cater for differing conditions.

[0021] Since the crankshaft is not uniformly stiff when subjected to side forces, there is a tendency for different amounts of material to be ground away in different planes, causing the crankpin to be ground to a non-round shape. Reducing the flow rate 32 during the final stage of grinding reduces the coolant pressure at the nozzle 14, and hence the force on the crankpin (when grinding forces are low already), and it has been found that the out-of-roundness of the crankpin can be reduced from approximately 10 microns to less than 1 micron, in terms of its true diameter. Thus, the invention enables a higher accuracy and truer grinding profile to be achieved than previously.

[0022] As an alternative to reducing the flow rate, as aforesaid, the coolant could be directed away from the wheel during the final grinding stage. However, it is believed that this alternative would be more complicated and less practical than reducing the flow rate.

Claims

1. A method of grinding a workpiece, comprising the steps of monitoring the grinding process, and during a predetermined final stage of a grind cycle, before final size is reached, altering the flow of coolant onto the region of the workpiece that is being ground for at least part of the duration of said predetermined stage of the grind cycle.

2. A method according to claim 1, in which altering the flow of coolant comprises reducing the flow to a fraction of the full flow, during said predetermined stage.

3. A grinding machine comprising a grinding wheel, drive means for rotating the wheel to effect grinding of a workpiece, means for rotating the workpiece during grinding, means for effecting relative movement between the grinding wheel and the workpiece to bring the wheel and workpiece into engagement for grinding and to maintain such engagement for the duration of a grinding cycle, means for directing a jet of coolant liquid onto the wheel or the workpiece or both, at least in the region of the engagement of the wheel and the workpiece, further comprising: coolant control means for controlling the rate of flow of coolant from the jet and/or the direction of the jet, sensing means for sensing when the grind cycle is nearing completion and the workpiece has a predetermined oversize condition remaining to be ground, means for generating a control signal responsive to signals from the sensing means, means for supplying the control signal to the coolant control means to alter the jet of coolant liquid so as to deflect, redirect, or reduce the jet or to shut the jet down completely when the predetermined oversize condition is sensed and for at least part of the duration of the remainder of the grind cycle.

4. A machine according to claim 3 and further comprising machine control means responsive to the control signal to resume the grinding cycle after the

alteration of the coolant jet has been effected, to complete the grinding process.

5. A machine according to claim 3 or claim 4, in which the sensing means comprises a workpiece engaging probe for detecting the dimension of a part of the workpiece which is being ground.

6. A machine according to any one of claims 3 to 5, in which the sensing means comprises means responsive to the advance of the grinding wheel during the grind cycle, which is programmed to deliver a signal when the grinding wheel has advanced through a given distance thereby indicating that said predetermined oversize condition has been reached during which coolant flow is to be altered.

7. A machine according to any one of claims 3 to 6 comprising a computer for controlling the grinding process, both the position of the grinding wheel relative to the workpiece and the distance to final size being available to the computer, wherein the coolant control means is controlled by signals from the computer.

8. A machine according to any one of claims 3 to 7, in which the coolant control means is a selector valve connected between a coolant pump and a nozzle for forming the jet, and operable to produce a full flow or a reduced flow of coolant.

9. A machine according to claim 8 further comprising a flow control valve upstream of the selector valve and operable to vary said reduced flow of coolant.

10. A machine according to any one of claims 3 to 9, in which the grinding wheel is a CBN wheel.

11. A method of grinding substantially as herein described with reference to, and as illustrated in, the accompanying drawings.

12. A grinding machine substantially as herein described with reference to, and as illustrated in, the accompanying drawings.

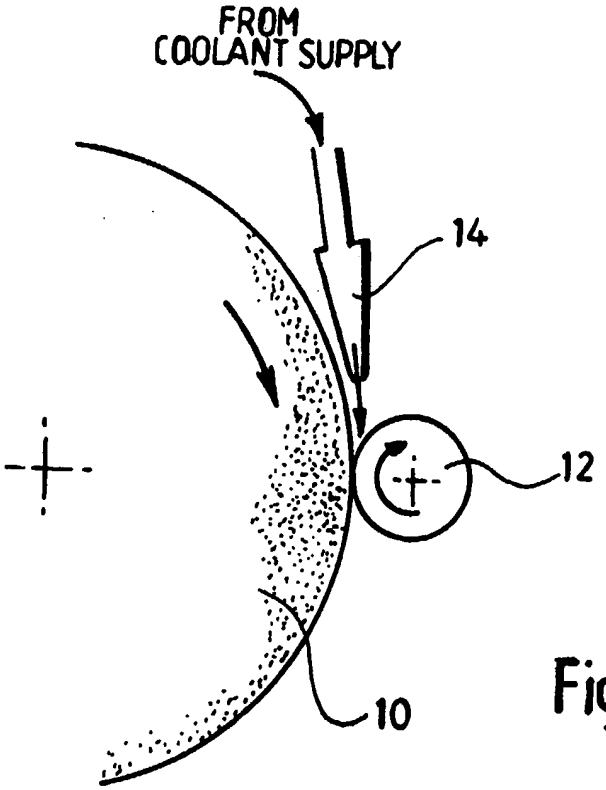
FROM
COOLANT SUPPLY
14
12
10

Fig. 1

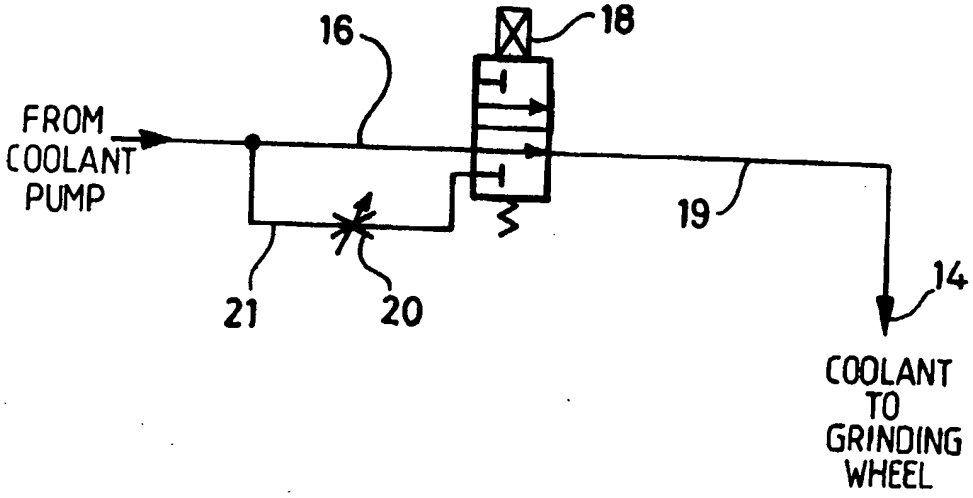
16
18
FROM
COOLANT
PUMP
19
14
21
20
COOLANT
TO
GRINDING
WHEEL

Fig. 2

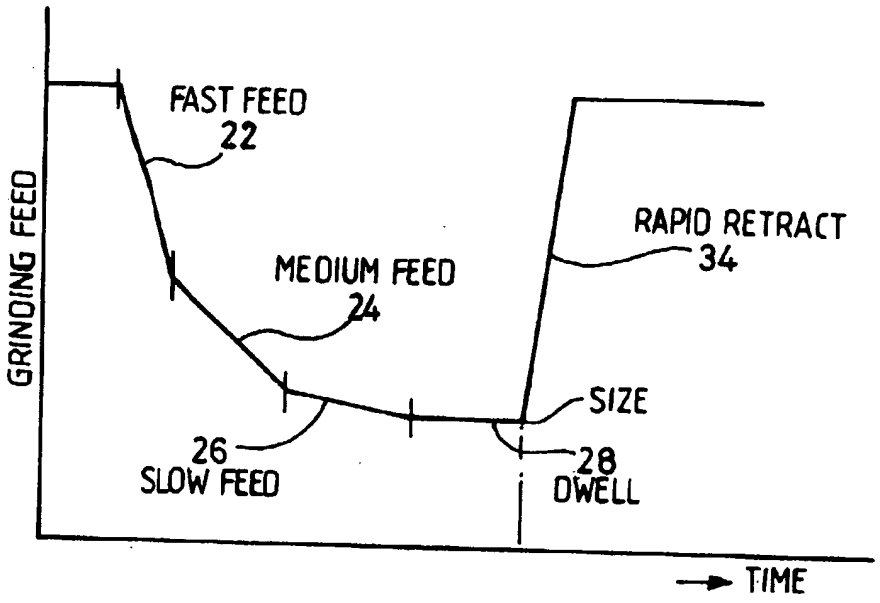
GRINDING FEED
FAST FEED
22
MEDIUM FEED
24
26
SLOW FEED
SIZE
28
DWELL
RAPID RETRACT
34
TIME

Fig. 3

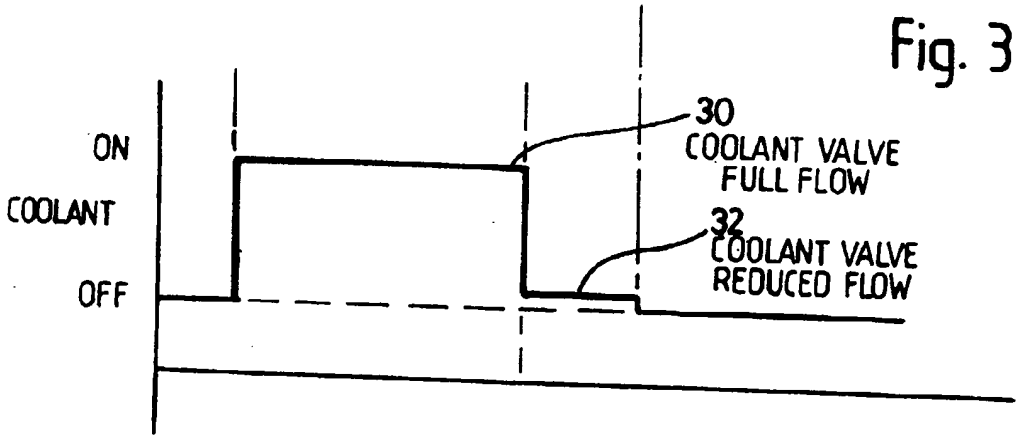
ON
COOLANT
OFF
30
COOLANT VALVE
FULL FLOW
32
COOLANT VALVE
REDUCED FLOW

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 98 30 7403

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
P,X	WO 98 09772 A (WESTERN ATLAS INT INC) 12 March 1998 * page 7, line 12 - page 9, line 4; figures *	1-4,6-9	B24B55/03 B24B57/02
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Y		5	
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TECHNICAL FIELDS SEARCHED (Int.Cl.6)

B24B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18 December 1998	Garella, M

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 30 7403

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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18-12-1998

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